



Original Article

Implementation of the Hammersmith Infant Neurological Examination in a High-Risk Infant Follow-Up Program



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ABSTRACT

BACKGROUND: High-risk infant follow-up programs provide early identification and referral for treatment of neurodevelopmental delays and impairments. In these programs, a standardized neurological examination is a critical component of evaluation for clinical and research purposes. **METHODS:** To address primary challenges of provider educational diversity and standardized documentation, we designed an approach to training and implementation of the Hammersmith Infant Neurological Examination with precourse materials, a workshop model, and adaptation of the electronic medical record. **CONCLUSIONS:** Provider completion and documentation of a neurological examination were evaluated before and after Hammersmith Infant Neurological Examination training. Standardized training and implementation of the Hammersmith Infant Neurological Examination in a large high-risk infant follow-up is feasible and effective and allows for quantitative evaluation of neurological findings and developmental trajectories.

Keywords: Hammersmith Infant Neurological Examination (HINE), high-risk infant follow-up, development, screening, neurologic examination, prematurity

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Introduction

The goal of high-risk infant follow-up (HRIF) programs is similar across continents and countries: they provide early identification and referral for treatment of neurodevelopmental delays and impairments to preterm infants or those with perinatal insults contributing to their developmental vulnerability. HRIF programs are also referral centers for general providers who have identified delays on routine screenings. A cornerstone of neurodevelopmental follow-up is the neurological examination, complemented

by various developmental and medical assessments. Using a standardized neurological examination common to all HRIF providers can further support diagnoses, provide a mechanistic understanding of disorders, help define prognoses, monitor the longitudinal history of a disease, and document the effects of interventions. Neurological examinations suitable for young infants after the neonatal and through the toddler periods have been developed for use in clinical care and research studies. They include the Touwen,¹ the Amiel-Tison,² and the Milani-Comparetti and Gidoni³ and the Hammersmith Infant Neurological Examination (HINE).⁴

Because the purpose of HRIF programs is to identify impairments as early and broadly as possible and to provide guidance for families, their choice of standardized assessment is heavily influenced by feasibility and prognostic considerations. In particular, examinations need to balance the demands of clinical imperatives and time constraints, at

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the same time as they fulfill the needs of research studies often associated with HRIF. We selected the HINE for implementation in the HRIF program at our institution because it is a well-studied neurological examination in

healthy or high-risk infants and can meet both our clinical and research needs (Table 1).

The HINE is an easily performed and relatively brief standardized and scorable clinical neurological examination

TABLE 1.
HINE Use in Infant Studies*

Study	Population	N	Sex Male (%)	GA (wk)	Months at Assessment	Comment
Amess et al. ⁵	Preterm infants	102	NR	28 (23–34)	Term 12	
Haataja et al. ⁶	HIE	53	29 (55)	Term	9–14	
Frisoni et al. ⁷	Preterm infants	74	NR	27 (24–30)	6–15	
Fowler et al. ⁸	Deformational plagiocephaly and control subjects	99	NR	32	4–13	
Gkoltsiou et al. ⁹	Kernicterus	11	6 (54)	5 Term, 6 preterm (35:27–36)	12–18	
Karagianni et al. ¹⁰	Preterm infants SGA, matched control subjects	41 SGA, 41 control subjects	21 (51)	32 (26–34)	18	Control subjects appropriate for GA
Karagianni et al. ¹¹	Preterm infants w/wo BPD	191	101 (53%)	≤32	6, 12	
Karagianni et al. ¹²	VLBW	174	93 (53)	29 ± 2	6, 12	
Leppänen et al. ¹³	VLBW preterm infants with abnormal fetoplacental flow	83	44 (53)	28 (23–34)	24	
Lind et al. ¹⁴	VLBW with postnatal caudothalamic cysts	5, 23 Control subjects	3 (60)	25–33	24	Control subjects (23) VLBW no HINE
Lind et al. ¹⁵	VLBW with and without NDI	164	82 (55%)	29 (No NDI), 27 (NDI) (23–35)	24	148 w/o NDI, 16 with NDI
Luciano et al. ¹⁶	Preterm (7), term (9)	16	NR	33.6	24	
Mathew et al. ¹⁷	Preterm infants	8	NR	31 (28–32)	42 wk	
Maunu et al. ¹⁸	VLBW/VLGA	225	54	28 (27–29)	24	
Pizzardi et al. ¹⁹	Preterm infants, neonatal encephalopathy	658	NR	34.8 ± 2.14	3, 6, 9, 12	
Ricci et al. ²⁰	Neonatal encephalopathy	15	67	Term	6	
Ricci et al. ²¹	Cystic PVL	24	NR	1 Term, 23 preterm, 30 (26–35)	6–9	
Romeo et al. ²²	Preterm infants (<37 wk)	903	55	34.5 ± 2.3	3	
Romeo et al. ²³	Cerebral palsy	70	64	Term, 32 (26–36)	3, 6, 9, 12	13 Term, 57 preterm
Romeo et al. ²⁴	Preterm infants	103	54	29 (25–31)	3, 6, 9, 12	
Romeo et al. ²⁵	NICU	1541	53	638 Term, 903 preterm (25–36)	3, 6, 9, 12	
Romeo et al. ²⁶	Near term	448	50	35–37	6, 9, 12	
Romeo et al. ²⁷	Low risk, VPI preterm	188	56	<37	3, 6, 9, 12	
Setänen et al. ²⁸	VPI	96	48	28 (26, 30)	24	
Spittle et al. ²⁹	Preterm, late preterm, term	80, 129, 201	48, 50, 52	33, 35, 39	48 h	

Abbreviations:

- BPD = Bronchopulmonary dysplasia
- GA = Gestational age
- HIE = Hypoxic ischemic encephalopathy
- HINE = Hammersmith Infant Neurological Examination
- NDI = Neurodevelopmental impairment
- NICU = Neonatal intensive care unit
- NR = Not reported
- PVL = Periventricular leukomalacia
- SGA = Small for gestation age
- VLBW = Very low birth weight
- VLGA = Very low gestational age
- VPI = Very preterm infants

* Table expanded and modified from Romeo DM, Ricci D, Brogna C, Mercuri E. Use of the Hammersmith Infant Neurological Examination in infants with cerebral palsy: a critical review of the literature. *Developmental Medicine and Child Neurology*. 2015 Aug 1.

for infants aged between 2 and 24 months, accessible to all clinicians, with good interobserver reliability even in less experienced staff. It has no associated costs such as lengthy certifications or proprietary forms. The English version of the HINE form as well as certified Spanish and French translations are available as supplementary material (see <http://dx.doi.org/10.1016/j.pediatrneurol.2016.09.010>). The use of the HINE optimality score and cutoff scores provides prognostic information on the severity of motor outcome. The HINE can further help to identify those infants needing specific rehabilitation programs. It includes 26 items assessing cranial nerve function, posture, quality, and quantity of movements, muscle tone, and reflexes and reactions. Each item is scored individually (0, 1, 2, or 3), with a sum score of all individual items (range 0 to 78). A questionnaire with instructions and diagrams is included on the scoring sheet, similar to the Dubowitz neonatal neurological examination.³⁰ Optimality scores for infants three to 18 months are based on the frequency distribution of neurological findings in a typical infant population: when an item is found in at least 90% of infants, it is considered optimal.⁴

Sequential use of the HINE allows the identification of early signs of cerebral palsy and other neuromotor disorders, whereas individual items are predictive of motor outcomes. For example, in preterm infants assessed between six and 15 months corrected age, scores greater than 64 predict independent walking with a sensitivity of 98% and specificity of 85%. Conversely, scores less than 52 were highly predictive of cerebral palsy and severe motor impairments.

Despite its general utility, the HINE currently lacks a standardized training or widely available course, prompting our team to design an education process for the follow-up clinic. The goal of this article is therefore to describe the training and implementation process of the HINE in an HRIF program, from challenges to solutions, educational tools, and metrics for success and opportunities for further improvement.

Methods

Patients and setting

The neonatal follow-up program at Nationwide Children's Hospital is an umbrella for three clinics addressing the needs of high-risk children, with more than 5000 yearly visits. One of these clinics is focused on optimizing the neurodevelopmental trajectories of infants within the context of their families. In this developmental clinic, infants are seen for a common neurodevelopmental journey at three to four months, nine to 12 months, 22 to 26 months, and 33 to 36 months corrected age for preterm infants and chronological age for all others (see Fig 1). Ideally, all visits include medical and neurological examinations, need assessment, and standardized testing by certified therapists (test of infant motor performance³¹ and general movements assessment³² at three to four months and Bayley Scales of Infant and Toddler Development, Third Edition,³³ at 12 to 36 months). Interim visits address specific developmental needs and include targeted standardized assessments. The team of medical providers, therapists, nurses, social workers, and dietitians together develop a multidisciplinary individualized plan. They ensure referrals to targeted early intervention services or research studies (e.g., high-intensity physical therapy,^{34,35} constraint therapy,³⁶ and Hanen programs^{37,38}) or to specialty provider evaluations (e.g., ophthalmology, audiology, and neurosurgery). In the two-year period before the study (January 2014 to December 2015), clinic personnel made 574 new developmental impairment diagnoses (excluding delays), with about two thirds of them motor or sensory (including cerebral palsy, muscle hypertonía or hypotonia, gait abnormality, vision, and hearing

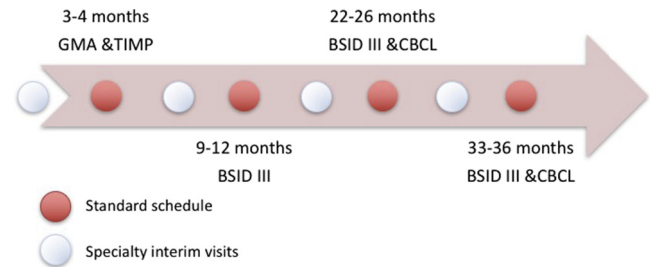


FIGURE 1.

High-risk infant follow-up schedule and assessments. From the neonatal intensive care unit to age 3 years, infants are followed using a standard schedule at 3 to 4, 9 to 12, 22 to 26, and 33 to 36 months. In addition, interim visits may be scheduled when specialty needs are identified. Ideally, every visit for developmental needs should have a standardized neurological examination. For a standard visit (red dots), both neurological and medical examinations should be performed in addition to the developmental history. At these visits, therapists perform a small set of standardized tests. For an interim specialty visit (blue dots), medical specialists address additional concerns (pulmonary, behavioral pediatrics, cerebral palsy, complex care, and feeding) and infants can receive a more diverse set of therapist assessments (e.g., Peabody Developmental Motor Scales, Gross Motor Function Measure, Infant Toddler Sensory Profile, or Receptive Expressive Emergent Language Test). Nutrition and social work assessments may also be required. For neurological examinations in the neonatal period, the Hammersmith Neonatal Neurological Examination is preferred, whereas for the 33- to 36-month visit, the Amiel-Tison is recommended in the literature. A simplified version better adapted to this older age group is feasible and is already partly available in electronic medical record, but does not produce a score. BSID, Bayley Scales of Infant and Toddler Development (Third Edition); CBCL, Child Behavior Checklist; GMA, General Movements Assessment; TIMP, Test of Infant Motor Performance. (The color version of this figure is available in the online edition.)

impairments). The clinic also participates in the follow-up studies of the Neonatal Research Network (NRN),³⁹ which requires its own examination and documentation at 22 to 26 months.

Identification of challenges

Challenges were identified through provider query using Survey Monkey.⁴⁰

Questions asked what were the challenges to performing a neurological examination in infants and what support could be provided to allow more effective performance of a neurological examination. Multiple nonexclusive choices were provided as well as space for open-ended answers. The goal of this survey was to obtain qualitative data. In addition, individual provider neurological examination documentations were compared to identify electronic medical record (EMR) strategies used. Identified challenges are reported in the Results section.

Intervention

Documentation

The electronic health record programming team (EPIC, Copyright 2016 Epic Systems Corporation) developed a standardized form, making the HINE a rapid and easy addition to the visit note. The documentation tool met both clinical and research needs. Drop down menus had item descriptions for easy scoring; sidebars included pictorial representations from the HINE form to enhance written descriptions; and a summary assessment was automatically extracted (Fig 2). Each item was coded as a unique field, making it easily extractable for research purposes. Individual items were also visible in EPIC as table or chart forms to facilitate clinical care and longitudinal views. The score for each domain and total HINE score was automatically calculated, with flagging of abnormal values at appropriate ages based on optimality scores. A modification to the published HINE form was inclusion of an asymmetry score (present in prior

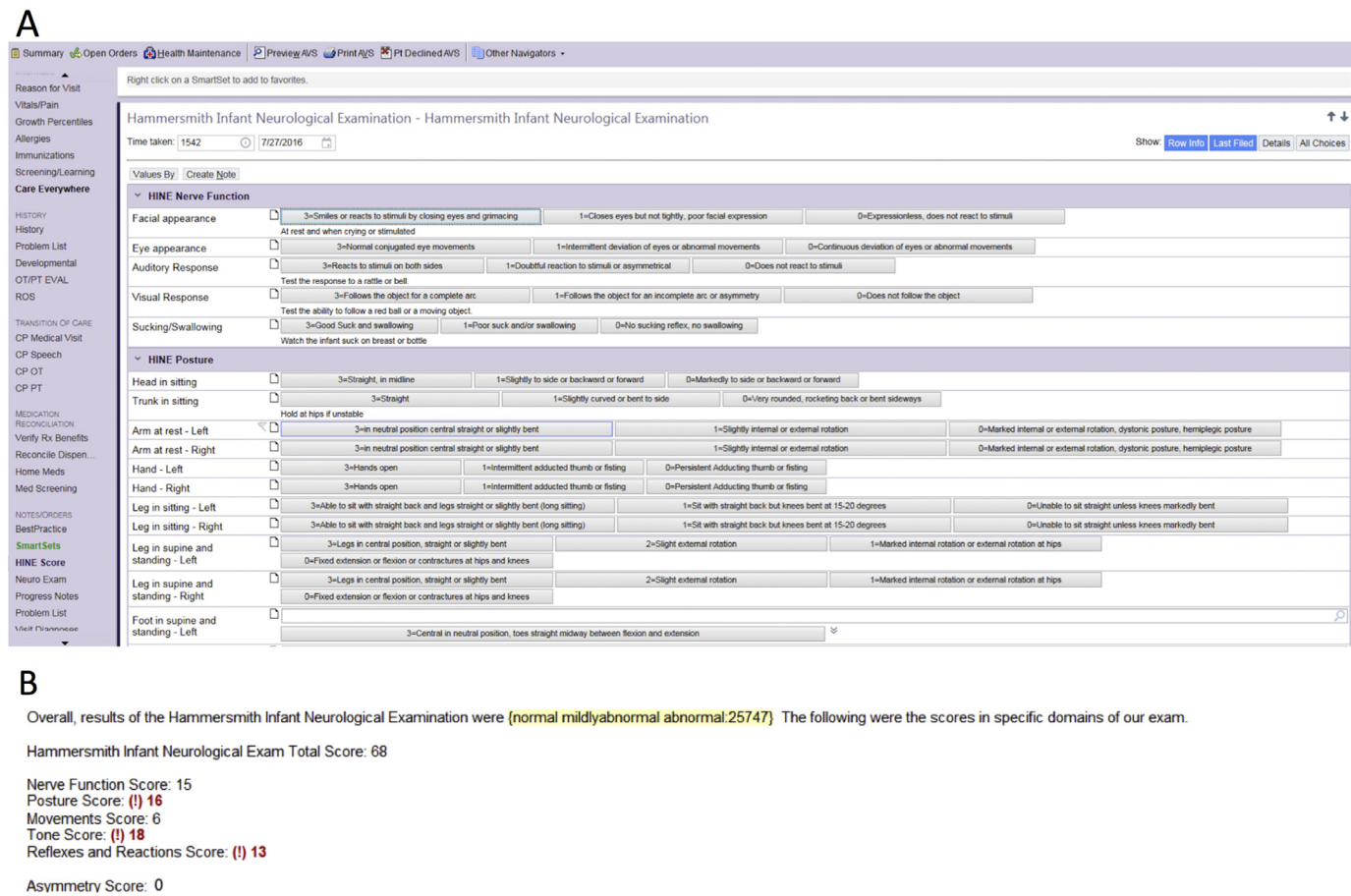


FIGURE 2. Electronic medical record representation of HINE scoring and report extracted into the clinic note. (A) Screen shot of the provider view of the medical record HINE form. Providers use drop down menus for each item to select a score and description of the item. Scores are abstracted by the EPIC program, and domain subscores are calculated. When left and right sides for individual items do not match, a score of 1 is added to the total asymmetry score. (B) Screen shot of HINE summary automatically extracted into the clinic visit note. Red color highlights scores less than the optimality score for age. No asymmetries were noted. HINE, Hammersmith Neonatal Neurological Examination. (The color version of this figure is available in the online edition.)

forms of the HINE⁴); this score corresponded to the total number of items on the HINE with dissimilar left and right side findings.

Provider and knowledge base diversity

A workshop was planned during which all providers would simultaneously be trained in the theoretical, research, and practical aspects of the HINE. This was not to be a certification but rather a continuing education project. Preparation for coursework, workshop training and

TABLE 2. Workshop Modules for Hammersmith Infant Neurological Examination (HINE) Training

Workshop Elements	Duration
Precourse work test	30 min
Lecture on supporting literature for utility of the HINE	30 min
Review of individual HINE item administration and scoring	45 min
HINE demonstrations with simultaneous videotaping (varied age and health status)	15 min per patient
Review of videotaped examinations and discussion of HINE item administration and scoring	20 min per patient
HINE video test	30 min

testing, and on-site training verification were essential components. This would allow the HINE to become the standard neurological examination across all age groups from three to 24 months and at all visits, even when elements of the NRN examination were performed to complete research requirements.

To overcome clarity issues in the published HINE form and ensure reliability, we designed a workshop (Table 2) with a neurologist instructor chosen who was trained by the developers of the HINE and had participated in published studies using the assessment.

Course design was based on models used in Neonatal Resuscitation program⁴¹ and Pediatric⁴² Advanced Life Support courses developed and regulated by the American Academy of Pediatrics and the American Heart association, respectively. First, a pre-workshop component included two articles describing the use of the HINE by experts in the field as well as the predictive value of the examination. The purpose of HINE implementation was to improve early identification in order to provide more rapid and targeted intervention. Therefore, a crucial component of this process was to improve the communication of HINE findings to the therapy assessment team to develop the multidisciplinary care plan. Therefore, the feeding, occupational, physical, and speech pathology therapy leaders were charged with compiling educational presentations on therapist training, scope of practice, standardized specialty assessments, and available evidence-based interventions. They also designed corresponding multiple-choice questionnaires to be administered before HINE training.

Second, the workshop opened with a didactic session explaining each component of the HINE, the purpose of the item tested, and the scoring

system for each individual item. This section was interactive and allowed providers to request clarifications and possible adaptations of the examination for special situations. In particular, the trainer addressed behavioral issues inherent to testing active toddlers or infants with stranger anxiety. The utility of the HINE in clinical practice was complemented by an overview of its use in research studies, its predictive value for diagnosing cerebral palsy.

The third part of the workshop included hands-on examination demonstrations of volunteer patients by the trainer, with direct observation and indirect viewing through a one-way mirror to allow the entire class to watch. Demonstrations of specific challenging items by trainees were permitted within the limits of infant and parent well being. For workshop participants to closely review and score the demonstrated examinations, they were videotaped and immediately uploaded for review in the classroom. Videotaped examinations were reviewed for individual item scoring, abnormalities, and difficulties in performing specific items, visualized adaptations, and trainee performance. Infants of varying ages and neurological status were recruited in order to review both normal and abnormal findings.

The final examination included videotaped items of children of varying age and health conditions. Examinees were asked to identify both the item being tested and the score that the item would receive on the HINE. Examples are provided in Fig 3 (Video 1), and a library of item administration on patients of varying age and neurological status is provided as a link in this journal.

Implementation verification

In the month before the start of the training program, we performed an EMR audit of provider documentation of 50 random charts for more than one month preceding the HINE workshop. This was a convenience sample representing at least four charts from each provider. An experienced neurodevelopmental provider with more than 10 years of practice with various neurological examinations including the HINE and the NRN examination audited only standard developmental visits. All provider types were included in the audit, including neurologists and developmental or behavioral pediatricians. We examined whether the five major domains of the HINE were scorable on the published paper form, using data recorded in the EMR. A score of 100% was given if the domain form could be filled out completely, a score of 50% if a domain examination was documented in a generic manner (e.g., “tone normal, moves all extremities well”), and a score of 0% was given when the domain was not addressed in the EMR. At 3 weeks after the training, most providers had practiced the HINE greater than 10 times on their patients and an experienced HINE practitioner observed each provider

performing the examination, giving feedback and answering questions as needed. After this, 50 random charts were again audited in the manner described previously. Comparisons before and after the intervention were performed using Wilcoxon rank sum test for logistic variables and two-tailed test for continuous variables, with alpha set to 0.01. We also queried the EMR database for more than an identical three-month period in 2014 and in 2016, before and after provider training to identify the number of new diagnoses of cerebral palsy and corrected age in months at diagnosis. We excluded 2015 data collection to prevent possible diffusion effects of enhanced awareness of early cerebral palsy detection during the planning phase of HINE training implementation.

Results

Challenges to implementation

Twelve providers returned survey data, and documentation of neurological examinations was reviewed for all providers. Most of the cited obstacles to HINE implementation could be grouped into three categories: (1) concerns about increasing time demands because of the documentation in the EMR, (2) inconsistent knowledge base about timing and specifics of the neurological examination because of provider-type diversity, and (3) concerns about a complex neurological examination decreasing the clinical flow without providing tangible benefits to patients. We examined the root causes of provider concerns and classified them as follows.

Consistency challenges

The medical provider base of the clinic is diverse in order to accommodate a highly variable mix of patients with general or specialized needs. All providers must be able to evaluate the neurodevelopment of high-risk patients and confidently know when to refer to specialty services and providers. The clinic medical team comprised advance practice nurses, general pediatricians, developmental/behavioral pediatricians, a pediatric neurologist, neonatologists, and specialty fellows in neonatology and developmental medicine. This diversity contributed to a lack of common language to describe neurological findings and a widely variable knowledge base in performing basic components of a neurological examination. The timing of neurological examinations was also inconsistent. Although providers often performed components of a neurological examination at 22 to 26 months, they rarely did so at three to four or nine to 12 months. Although therapists were provided with a clearly defined schedule of standardized assessments (see Fig 1), medical providers did not have an equivalent algorithm. Finally, the neurological examination administration sometimes depended on whether patients were participating in research studies. For example, the NRN³⁹ study patients followed in the clinic received a standardized research examination based on the Amiel-Tison.² Because of the length of the NRN examination, providers stated that consistent use of this examination at every visit would slow the flow of patients. Furthermore, it was designed only for a 22- to 26-month visit and some items such as gait observations or pincer grasp did not apply to three- to four-month infants.



FIGURE 3.

Demonstration of the HINE assessment items. The HINE examiner can assess a child in their parent's lap if it reduces infant stress. To obtain demonstrations of all items in several children of varied ages and health conditions, click on embedded link. HINE, Hammersmith Infant Neurological Examination. Supplementary video related to this article can be found at <http://dx.doi.org/10.1016/j.pediatrneurol.2016.09.010>. (The color version of this figure is available in the online edition.)

TABLE 3.

Completion of Hammersmith Infant Neurological Examination (HINE) Elements Before and After Training

HINE Scorable Element	% Documented Before Training	% Documented After Training
Nerve function	54	92*
Movements	41	88*
Reflexes and reactions	22	92*
Posture	41	87*
Tone	33	92*
Total average	37	90*

* All $P < 0.01$ on Wilcoxon rank test.*Documentation challenges*

The EMR was originally designed to include a standard neurological examination, with multiple choices appropriate for older children or adolescents but not for developing infants aged between three and 24 months. To circumvent this issue, one provider used the HINE at all visits but documented it in a free text format with item descriptions and without scores. Because most high-risk infant visits are time consuming, providers were also reluctant to use any system that excessively slowed or complicated documentation. Again, providers stated that the NRN examination form was lengthy and adding it to every visit would excessively increase the time burden of documentation by an estimated five to six minutes per patient.

Challenges inherent to the HINE

The examination has a published questionnaire with graphics but no user manual. The stick figures representing the positions of the patients are not always self-explanatory and the small descriptions under each item name are brief. No reference currently exists for clarification purposes. With two exceptions, the providers had never heard of the HINE and of its advantages for clinical diagnosis.

Efficacy of implementation

Children ages three to four months, nine to 12 months and 22 to 26 months, provider types, and days of the week were represented equally. Completion of HINE domains was improved after training (Table 3). Before and after implementation, documentation in patients who received the NRN neurological examination resulted in 80% of HINE completion. This was because of an imperfect overlap between the two examination forms. After training, ten of 50 visits did not have a completed HINE EMR form, with one of ten having the NRN form instead, and nine of ten representing three providers. Primary reason for not documenting the examination was reported as nonawareness of the EMR form and secondary as not knowing if the examination should be performed at all visits.

When comparing the identical 3-month period before implementation of the program and postimplementation, we found a comparable number of new cerebral palsy diagnoses in the same period relative to patient volume (2.2% vs 2.6%, $P = 0.41$). However, the mean age at diagnosis pre-

HINE was significantly lowered ($P < 0.001$) from a pre-HINE mean of 27.9 months (SD 1.8, range 23 to 30) to a post-HINE of 15.7 months (SD 7.1, range 4 to 29).

Postimplementation feedback

During the three-week period after the training, a trained HINE examiner available in the clinic questioned the providers. With regards to knowledge base, providers were asked if they wanted the examiner to confirm their examination. Four providers requested this. With regards to time management concerns, providers were asked if these concerns were still present. Most replies were that the examination was short and easily performed during a routine visit. Concerns remained about the documentation, as each item required scoring, sometimes on both sides. One provider stated that this added two to three minutes to the documentation time per patient. One comment was a request to build a “one-click option” if all items were normal to decrease documentation time. The request was considered and discussed with the two neurology experts in the HINE, but was eventually not implemented. Reasons for the refusal were that a one-click option would not promote performing the full examination every time, not recognize the fact that even typically developing children have variations in optimality scores, not reinforce the knowledge of the examination that is obtained by reading items repeatedly, and that it may increase the risk of missing slight asymmetries.

Discussion

HINE training and implementation in an HRIF clinic is feasible and effective when combined with EMR adaptation. A workshop model preceded by targeted coursework and postworkshop feedback allowed a wide variety of medical providers to be effectively trained. The elements of (1) relative brevity compared with other examinations, (2) optimality score for clinical and research purposes, and (3) predictive value for diagnosis of cerebral palsy make the HINE unique among neurological assessments in the first two years.

The relative brevity of the examination with only 26 items (compared with 35 in certain age groups on the Amiel-Tison) and the relative ease of documentation make it well suited for clinical practice. Rather than scoring items on whether they are typical, moderately abnormal, or abnormal for age, HINE scoring is based only on observation of item performance. Optimality score is then determined based on the child's age.

New international guidelines and recommendations for early detection of cerebral palsy (International Conference on Cerebral Palsy and Other Childhood-Onset Disabilities, Stockholm, June 2016)⁴³ state that the HINE is the most predictive neurological examination for cerebral palsy and is recommended in the first year of life, when a General Movements Assessment cannot be performed at three to four months. In our setting, the mean age at diagnosis was lowered by 12.2 months on average, but the overall frequency of diagnosis after HINE implementation remained the same. The HINE may increase diagnostic precision, but does not appear to result in an overdiagnosis. Other factors

may have played a role in this apart from the examination itself, such as increased awareness of the need for early diagnosis after the didactic teaching component of the HINE use for cerebral palsy detection. Earlier diagnosis allowed earlier referral to intervention services and parent support. Given the nature of HRIF clinics as follow-up for neonatal intensive care units and referral centers for community pediatricians, they are often the first setting in which cerebral palsy is diagnosed⁴⁴ and neonatal intensive care unit graduates constitute 50% to 70% of all new diagnoses. Implementation of the HINE in HRIF may therefore facilitate earlier detection and intervention at a regional level.

Opportunities for improvement in the model included clearer communication of EMR changes to providers during the course with a demonstration of the scoring, data retrieval, and longitudinal view possibilities. Another opportunity to streamline the documentation process included the addition of HINE items missing from other research assessments such as the NRN to the EMR.

To maintain and build on current training, a professional videographer from the Department of education at Nationwide Children's Hospital filmed the workshop examinations to begin a video library, included in this article. This library will allow continued education, yearly retraining, and standardization to prevent drift in the standardized use of the HINE. During regular clinic visits, additional videos of the HINE obtained with informed consents approved by the Institutional Review Board will help document variations because of age groups and health conditions, and expand the video library.

New provider HINE training will be addressed with an individual version of the workshop, modeled on the currently described one and administered by the most experienced HINE examiners. A refresher course for those previously trained will include the instructor presentation, videos from the library, and a test involving scoring a standardized videotaped examination. The clinic currently uses the same model of an annual 1-hour video refresher followed by scoring of a videotaped examination for NRN certification. In addition, as with the NRN examination, an experienced practitioner will shadow and provide feedback on provider request. For research studies, an additional review of videotaped examinations of participating providers would be necessary to establish inter-rater reliability. New research on the HINE (e.g., correlations with the General Movements Assessment) will be added to the yearly educational program and to the clinic's operation manual.

Conclusions

We present a feasible training and implementation program for the HINE in an HRIF clinic in the United States. We do not propose that this model should be implemented in its entirety in all settings. Clinics with fewer providers may wish to use the didactic component only and perform the patient demonstrations with videotaping during clinical practice. Others may consider the use of simulation models, especially when teaching a large number of inexperienced trainees. The number of demonstrations in the workshop can be adjusted to the number of trainees to allow hands-on learning reinforcement. A tailored approach to implementation of this clinical and research tool should allow its

use in multiple settings throughout the world. The [Video 1](#) included in this article represent testing of each item on patients of different ages and health status, and may prove useful to others designing their own training course.

Finally, the HINE was chosen as the neurological examination with the greatest research and clinical potential for our population, and as the easiest to perform. However, the HINE did not have a user's guide. Although this does not constitute a problem for highly trained and experienced neurologists who use this examination routinely, it increased the challenge of training and training verification in our HRIF clinic setting. Each item needed to be described fully, visualized, and performed consistently, and recorded for future benchmarking. This necessitated the engagement of experts who routinely use the HINE in both clinical and research settings to ensure fidelity with published clinical and research metrics. Future opportunities for improvement of the program could therefore include the development of an administration manual by published experts in the HINE and a shared video library for online training courses.

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Supplementary material

The English version of the HINE form along with certified French and Spanish translations of the form are available as supplementary material at <http://dx.doi.org/10.1016/j.pediatrneurol.2016.09.010>.

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